Bharatiya Vidya Bhavan's

SARDAR PATEL COLLEGE OF ENGINEERING

(Government Aided Autonomous Institute under Mumbai University) Andheri (W), Mumbai – 400058

COURSE CONTENTS

Sem. VII

B. Tech. (ELECTRICAL) ENGINEERING

R22

From Academic Year 2025-2026

List of Courses

Course Code	Course Name
PE-BTE701	**Advanced Electric Drives**
Course pre-requisites	Power Electronics, Electric Drives

Course Objectives

Objectives of this course are

1. Discuss the operation of power electronic converters and their control strategies.
2. Introduce vector control strategies for ac motor drives
3. Discuss the implementation of the control strategies using digital signal processors

Course Outcomes

Upon successful completion of the course, students will be able to

1. Compare the operation of power electronic converters and their control Strategies.
2. Demonstrate the modelling of rotating ac electrical machines
3. Asses the scalar control and vector control strategies (field oriented control and direct torque control) for ac motor drives and use of digital signal processors in implementation

Module No.	*Details*	*Hrs.*
1	**Power Converters for AC drives** Modelling of three phase inverter. Control techniques of inverter: Square wave inverter operation, Sine –triangle PWM technique, Space vector modulation, Comparison of control techniques, Selective harmonic elimination technique, Current control of VSI, Three level inverter, Different topologies, SVM for 3 level inverter	08
2	**Mathematical Modelling of Induction Machines** Different transformations and reference frame theory, Development of mathematical model of induction machine in different reference frame, torque equation of induction motor in different reference frame	06
3	**Control of Induction Motor Drives** Voltage fed inverter control-v/f control (scalar control), Analogy of DC drive for the vector control of induction motor, Different field oriented control (FOC) techniques of induction motor, Comparison of scalar and vector control, Direct torque and flux control (DTC). Comparison of field oriented control (FOC) and direct torque control (DTC).	10
4	**Synchronous Motor Drives** Modelling of synchronous machines, Open loop v/f control, Vector control, Direct torque control, CSI fed synchronous motor drives	04
5	**Permanent Magnet Motor Drives** Introduction to various PM motors, BLDC and PMSM drive configuration, comparison, block diagrams, Speed and torque control in BLDC and PMSM	06
6	**Switched Reluctance Motor Drives** Evolution of switched reluctance motors, Characteristics of SRM, Various topologies for SRM drives, Comparison, Closed loop speed and	04

	torque, Control of SRM	
7	**DSP Based Motion Control** Use of DSPs in motion control, various DSPs available, and Realization of some basic blocks in DSP for implementation of DSP based motion control.	**0**4

For Self-study: Mathematical Modelling of PMSM, SRM, BLDC

Term work contains 6-8 tutorials based on syllabus.

Text Books
1. G. K. Dubey, "Power Semiconductor Controlled Drives", Prentice Hall. 2. R. Krishnan, "Electric Motor Drives: Modeling, Analysis and Control", Prentice Hall. 3. B.K. Bose," Modern power electronics and ac drives", PHI
Reference Books
1. G. K. Dubey, "Fundamentals of Electrical Drives", CRC Press. 2. W. Leonhard, "Control of Electric Drives", Springer Science & Business Media. 3. Subrahmanyam V, Electrical Drives: Concepts and Applications TMH 4. Pillai S.K, A First course on Electrical Drives Wiley Eastern PH 5. P.C. Krause, 'Analysis of electric machinery and drives system', Wiley

Course Code	**Course Name**
PE-BTE702	**Computer Aided Power System Analysis**
Course pre-requisites	PSA, PSOC, Numerical techniques, programming skills
Course Objectives	
The objectives of this course are 1. To understand analysis of power systems using Computer methods. 2. To understand the advance techniques in the solution of power flow problem.	

3. To understand the solution methods and techniques involved in power system analysis.
4. To understand the behavior of power system under healthy and faulty condition.

Course Outcomes

At the end of the course, students will demonstrate the ability to

1. Apply numerical techniques, matrix computation and optimization in the field of power system
2. investigate the behavior of power system under different operating conditions with software aid.
3. analyze the power system under symmetrical and unsymmetrical fault condition using Zbus
4. evaluate state of the complex power system by various state estimation tools.
5. interpret simulation/program results to make informed decisions regarding system planning, operation, and control.

Course Content

Module No.	***Details***	***Hrs.***
1	**Mathematical concepts:** Numerical methods to solve non-linear equation: Gauss-Seidel, Newton Raphson method, Optimization Methods: Nonlinear constraint optimization, Lagrangian Multiplier approach, Linear programming, Least square Estimation	5
2	**AC Power Flow Analysis:** Preparing/using data files required for power flow studies such as line data, generation data, bus data. Ybus matrix formation, Power flow solution algorithms such as Gauss Siedel, Newton Raphson, Fast Decoupled and DC power flow for multi- machine or IEEE systems. Power flow studies for distribution systems.	6
3	**Analysis of Faulted Power System:** Symmetrical and Asymmetrical Faults, Zbus Formulation, Short Circuit Analysis of Large Power Systems using Zbus.	5
4	**Power System stability:** Numerical solution of Swing equation using Forward Euler method, Runge-kutta 4^{th} order method, stability study of multi-machine system.	6
5	**Load Forecasting Techniques:** classification of forecasting, Introduction to time series, Linear regression, forecasting methodologies, estimation of average, trend & periodic components, time series approach, kalman filter approach, long term load forecasting for system planning. Introduction to Machine learning approach for load forecasting. Error analysis in load forecasting.	8
6	**Power System State Estimation**: Introduction, Network Topology Processing, observability analysis, Linear state estimation	6
7	**Security Analysis:** Basic Concepts, Static Security Analysis at Control Centre, Contingency Analysis, Contingency Selection.	6

For Self-study: Sparse Matrices: Sparsity directed Optimal Ordering Schemes, Solution Algorithms – LU Factorization

Text Books:

1. Saadat Hadi, “Power System Analysis, “TMH Publication.
2. Kothari D. P Nagrath I. J., “Modern Power System Analysis”, TMH Publications.

Reference Books:

1. A. R. Bergen and Vijay Vittal, “Power system analysis”, (2nd edition), Pearson Education Asia, 2001.

2. J. D. Glover and M. Sarma ,"Power System Analysis and Design ", (3rd Edition), Brooks/ Cole Publishing,2002

E resources (if any):

Forecasting: Principles & Practice by Rob J. Hyndman & George Athanasopoulos
https://otexts.com/fpp3/

Introduction to Time Series and Forecasting
https://link.springer.com/book/10.1007/978-3-319-29854-2

https://www.gridlabd.org/

https://smartgrid.ieee.org/bulletins/may-2021/multi-agent-opendss-an-open-source-and-scalable-distribution-grid-platform

Course Code	Course Name
PE-BTE703	**Smart Grid**
Course pre-requisites	Power System, Distributed Generation and micro-grid

Course Objectives

The objectives of this course are

1. Discuss smart grid characteristics, opportunities and barriers
2. Introduction to smart meters, smart substations
3. Discuss micro grid, distributed energy resources, power quality management in smart grid.

Course Outcomes

Upon successful completion of the course, students should be able to

1. Explain the concept and significance of smart grid in modern power systems.
2. Identify and describe the key components and technologies used in smart grid infrastructure.
3. Analyze the operation of microgrid, integration of distributed energy resources, and approaches for power quality management.
4. Evaluate the role of communication technologies and cybersecurity in the effective functioning of smart grids.

Course Content

Module No.	*Details*	*Hrs.*
1	Introduction to Smart Grid	**06**

	Evolution of Electric Grid, concept of Smart Grid, definitions, need of Smart Grid, functions of Smart Grid, opportunities and barriers of Smart Grid, difference between conventional and Smart Grid, concept of resilient and self-healing Grid, present development and international policies in Smart Grid, Case studies of Smart Grid, CDM opportunities in Smart Grid.	
2	Smart Grid Technologies Part I Introduction to Smart Meters, real time prizing, Smart appliances, Automatic Meter Reading (AMR), Outage Management System (OMS), Plug in Hybrid Electric Vehicle (PHEV), Vehicle to Grid, Smart sensors, Home and building automation, Phase shifting transformers.	**06**
3	Smart Grid Technologies Part II Smart substations, substation automation, feeder automation, Geographic Information Systems (GIS), Intelligent Electronic Devices (IED) & their application in monitoring & protection, Smart storage like Battery, SMES, Pumped Hydro Compressed Air Energy Storage, Wide Area Measurement System (WAMS), Phase measurement unit (PMU).	**06**
4	Micro grids and Distributed Energy Resources Concepts of micro grid, need and applications of micro grid, formation of micro grid, issues of interconnection, protection and control of micro grid, Plastic and organic solar cells, thin film solar cells, variable speed wind generators, fuel cells, micro turbines, captive power plants, integration of renewable energy sources.	**06**
5	Power Quality Management in Smart Grid Power quality & EMC in Smart Grid, power quality issues of grid connected renewable energy sources, power quality conditioners for Smart Grid, Web based Power Quality monitoring, Power quality Audit.	**06**
6	Information & Communication Technology for Smart Grid Advanced Metering Infrastructure (AMI), Home Area Network (HAN), 6. Neighbourhood Area Network (NAN), Wide Area Network (WAN), Bluetooth, Zigbee, GPS, Wi-Fi, Wi-Max based communication, Wireless mesh network.	**06**
7	Security for Smart Grid Basics of CLOUD computing and cyber security for Smart Grid, Broadband over Power Line (BPL), IP based protocols.	**06**
Term Work		
Term work shall comprise of 1. Tutorials 2. MCQ examination		

Text Books
1. Ali Keyhani, Mohammad N. Marwali, Min Dai, "Integration of Green and Renewable Energy in Electric Power Systems", Wiley. 2. Clark C. Gellings, "The Smart Grid – Enabling Energy Efficiency and Demand Response" CRC press. 3. Janaka Ekanayake, Nick Jenkins, KithsiriLiyanage, Jianzhong Wu, Akihiko Yokoyama, "Smart Grid – Technology and Applications", Wiley.
Reference Books
1. Jean Claude Sabonnadière, NouredineHadjsaid, "Smart Grids", Wiley Blackwell. 2. Peter S. Fox, Penner, "Smart Power – Climate Changes, the Smart Grid and the

Future of Electric Utilities", Island Press, 1st Edition 8th June 2010.
3. Stuart Borlase, "Smart Grids (Power Engineering)" CRC Press.
4. S.Chowdhury, S. P. Chowdhury, P. Crossley, "Microgrids and Active Distribution Networks", Institution of Engineering and Technology, 30th June 2009.

Course Code	Course Name
PE-BTE704	**Industrial Automation**
Course pre-requisites	Control System

Course Objectives

The objectives of this course are
1. Understand architecture of industrial automation systems.
2. Overview of industrial control systems.
3. Learn elements of automation systems.
4. Understand performance objectives of process automation.

Course Outcomes

Upon successful completion of the course, students should be able to
1. Describe architecture and levels of Industrial Automation systems..
2. Tune PID controller and interpret Process & Instrumentation diagrams.
3. Identify and describe the components of an automation system including controllers, HMIs, IT infrastructure and communication protocols.
4. Explain design methodologies and performance objectives for industrial automation systems.

Course Content

Module No.	***Details***	***Hrs.***
1	Introduction: Industrial Automation and Control and Architecture of Industrial Automation Systems	**05**
2	Industrial Control System: P, I, D controller capabilities, Practical aspects, Tuning with reference to Process Control.	**05**
3	Process representation: P & I Diagrams and Interpretation, Functional or Process Block diagrams.	**08**
4	Performance objectives: Response times (At various levels) Availability Calculation for the System (MTBF & MTTR) Resolution, Linearity, Accuracy. Design methodology: User Requirement Specifications (URS), System (Or Software) Requirement Specifications (SRS) Factory & Site Acceptance Tests (FAT & SAT), Quality Assurance System	**06**
5	Elements Industrial Automation (a) Five tier concept (Sensors to Boardroom) Field Devices (Instruments, IEDs, Lab Equipment etc, Smart & Conventional) Controllers (PLC, DCS, RTU, DDCs) SCADA/HMI & Database.	**06**

6	Elements Industrial Automation (b) Higher level applications (MIS/MES/Optimization / ERP etc) IT Infrastructure (Servers, Work Stations, Engineering Stations, Gateways, FEP, Communication Networks) Protocols: 7 layer model, TCP/IP Ethernet, Modbus TCP/IP & RTU, - Profibus, IEC61850, BACNet , OPC etc	**06**
7	Case Study(Any one) –Electric Drives : Introduction, Energy Saving with Adjustable Speed Drives - Introduction to Production Control Systems - Introduction to CNC Machines	**06**
Term work		
Term work shall comprise of 1. Tutorials 2. Simulation on PID controller tuning 3. DCS and PLC programs 4. MCQ examination / mini project *Mini project: There will be a course project where the students will be able to apply and integrate the knowledge gained during the course. The projects will be developed by teams of Two to Four students and will consist of design of any one Automation application		

For Self-study: DCS Programming

Text Books:

1. Industrial Instrumentation, Control and Automation, S. Mukhopadhyay, S. Sen and A. K. Deb, Jaico Publishing House, 2013
2. Programmable controllers: Principle and Applications, Webb J.W, PHI New Delhi
3. Industrial Electronics, Thomos E. Kissell, PHI.

Reference Books:

1. Chemical Process Control, An Introduction to Theory and Practice, George Stephanopoulos, Prentice Hall India, 2012.
2. Process Control Instrumentation, Curtis . D. Jhonson, Pearson (8th edition)
3. Electric Motor Drives, Modelling, Analysis and Control, R. Krishnan, Prentice Hall India, 2002
4. Hydraulic Control Systems, Herbert E. Merritt, Wiley, 1991
5. PID Controllers: Theory, Design, and Tuning, Karl Astrom and Tore Hagglund
6. Industrial Instrumentation and Control By. S.K. Singh The McGraw Hill Companies.
7. Industrial Electronics and Control, S K Bhattacharya, S Chatterjee, Ttti Chandigarh.

E resources (if any):

https://archive.nptel.ac.in/courses/108/105/108105088/
https://ial-coep.vlabs.ac.in/

Course Code	Course Name
PE-BTE711	**Vehicular Systems and Control of EV Drives**

Course pre-requisites	Electrical Machines-I and II, Power Electronics

Course Objectives

The objectives of this course are
1. To explore and understand various traction motors, power drives and control strategies used in EVs.
2. To get conversant with the energy sources used in EVs and their state of the art.
3. To understand the various battery charging and management systems

Course Outcomes

Upon successful completion of this course, the learner will be able to:
1. Assess various traction motors along with their suitability in various EV segments.
2. Criticize various power converters and their control used in EV drives
3. Illustrate different battery charging methods and protocols and the impact of large scale integration of EV charging infra in existing grid.
4. Appreciate vehicle control unit for smooth operation & human safety as per regulatory standards

Course Content

Module No.	***Details***	***Hrs.***
1	**Introduction to Traction Motors:** DC Machines- Brushed and Brushless DC motors (BLDC); AC Motors: Induction motors (IM), permanent-magnet ac synchronous motor-surface-permanent-magnet (SPM) motors and interior-permanent-magnet (IPM) motors; PM Materials; Switched Reluctance Motor (SRM); Basic construction details and working principles of each of the machine. In-Wheel Motors ,Comparison of Traction Machines; Specifications of the motors, Characteristic Curves of a Machines: Constant-Torque Mode, Constant-Power Mode; Efficiency Map; Suitability of each machine in Electric vehicle domain for 2W, 3W, 4 wheeler and large size vehicles. Real life examples; Review of advancement in EV Motors and Drives.	**8**
2	**Power Converters for EV drive:** Power Conversion –Basic Principle, review of DC-DC converters, DC-AC Converters used in EV applications; Power converter topologies for IM, BLDC, PMSM and SRM motors. Modulation schemes: Sinusoidal Pulse Width Modulation, SPWM with third harmonic injection, Space vector modulation, comparison of modulation techniques. Converter / Inverter Loss calculation, Heat-sinking: passive and active cooling.	**8**
3	**Control of Power Converters and Motors:** Induction Motor Control: Variable-Voltage Variable-Frequency Control (VVVF), Field-Oriented Control (FOC), Direct Torque Control (DTC); PM Synchronous Motor Control: Field-Oriented Control of PMSM, Flux-Weakening Control of PMSM, Position Sensor-less Control of PMSM. SRM motor control: Current chopping control (CCC), Torque-	**8**

	Ripple Minimization Control BLDC Motor Control*:* Trapezoidal back EMF BLDC motor control	
4	**Battery charging Infrastructure:** AC and DC charging, CC-CV charging, Pulse charging; On-board and off-board charging; Standards and protocols for charging; Fast DC chargers, Home and Public charging infrastructure; Wireless power transfer (WPT) technologies for EVs, Move-and-charge technology. Charging Infrastructure-standardization and connectivity issues; SAE J1772, CHAdeMo, GB/T, CCS2 battery charging protocols. OCPP protocol Impact on existing power grid, G2V and V2X- Vehicle-to-home (V2H), vehicle-to-vehicle (V2V), and vehicle-to-grid (V2G) energy systems. Renewable Energy Based Charging infra.	**8**
5	**EV Drive Cycle Testing:** Need for a driving cycle, different Drive Cycles: New European Driving Cycle (NEDC), The Extra-Urban Driving Cycle (EUDC), EPA, WLTP, and FTP-75, Testing of EV for range per charge for a given drive cycle.	**4**
6	**Vehicle Control Unit and Electronic Control Unit:** VCU functionality: Inverter control, battery management, charging control, vehicle functions in transmission and engine control; Advanced Driver Assistance System (ADAS); Electronic control units (ECUs): Various Section ECUs and their networking; Body and Lighting ECU (Key-less Entry, Sonar, HID, LED Lamps), Body ECU (Airbag).	**4**
7	Regulatory standard and engineering standards for EV. Automotive Industry Standard (AIS) for electric vehicles in India (Some of the regulations are AIS038, 039, 040, 041, 048, and 049)	**2**

Text/Reference Books:-

1. Fundamentals And Applications Of Lithium-Ion Batteries In Electric Drive Vehicles by Jiuchun Jiang and Caiping Zhang, Wiley, 2015

2. Battery Management Systems for Large Lithium-Ion Battery Packs, by Davide Andrea, Artech House Publication, 2010

3. Electric Vehicle Battery Systems by Sandeep Dhameja, Newens, 2002

4. Fundamentals And Applications Of Lithium-Ion Batteries In Electric by Jiuchun Jiang and Caiping Zhang, Wiley, 2015

5. Optimal Charging Control of Electric Vehicles in Smart Grids by Wanrong Tang and Ying Jun Zhang, Springer, 2017

6. Plug In Electric Vehicles in Smart Grids Charging Strategies Edited by Sumedha Rajakaruna, Farhad Shahnia and Arindam Ghosh, Springer 2015

7. Technologies and Applications for Smart Charging of Electric and Plug-in Hybrid Vehicles edited by Ottorino Veneri, Springer, 2017

8. Solar Powered Charging Infrastructure for Electric Vehicles A Sustainable Development Edited by Larry E. Erickson, Jessica Robinson, Gary Brase, and Jackson Cutsor, CRC Press, 2017

9. Energy Systems for Electric and Hybrid Vehicles Edited by K.T. Chau, IET, 2016

10. Handbook of Automotive Power Electronics and Motor Drive Edited by Ali Emadi, CRC Press, 2005

Course Code	Course Name
PE-BTE712	**Restructuring and Deregulation of Power System**

Course pre-requisites	Power system-I and power system –II

Course Objectives

The objectives of this course are

1. To differentiate between vertically integrated and deregulated power system.
2. Challenges faced in operating restructured power system with reliability, security and economic efficiency.
3. Reforms adopted by developing country like India.

Course Outcomes

Upon successful completion of the course, students will be able to

1. Classify various types of **electricity market designs** and **contrast** the perspectives of **consumers** and **producers** within these markets.
2. Apply the **fundamental principles of microeconomics** to analyse decision-making and market behavior in the power sector.
3. Compare and evaluate **pricing methods** used in **centralized and decentralized**

electricity trading systems.

4. Appraise the significance and functionality of **ancillary services** in maintaining **grid stability and reliability.**
5. Ascertain the use of **optimization** in engineering and decision-making problems.

Course Content

Module No.	*Details*	*Hrs.*
1	**Introduction of restructured power system.** • Reasons for restructuring and deregulation of power system • Entities involved • Different model of competition • Electrical market vis-à- vis market of commodities	**6**
2	**Fundamentals of micro economics** • Consumer behaviour • Supplier behaviour • Market equilibrium • Various cost of production • Long term and short-term cost • Types of markets • Markets with imperfection competition	**8**
3	**Introduction to optimization** • Linear optimization • Convexity • Duality • KKT condition • Lagrange multiplier • Optimal dispatch of generation	**6**
4	**Optimal Power Flow and Congestion Management.** • Optimal power flow – AC and DC formulation • Spot Pricing • Decentralized trading over the transmission network. • Centralized trading over the transmission network.	**8**
5	**Participating in markets for electrical energy** • Consumer's perspective • Producer's perspective	**4**
6	**System security and ancillary service** • Ancillary service needs • Obtaining ancillary service • Buying ancillary service • Selling ancillary service	**5**
7	**Reforms in Indian Power Sector** • Frame work of Indian power sector • Electricity act 2003 and amendments • Transmission system cost allocation • Power exchanges – Day ahead market, real-time market • Deviation settlement mechanism	**5**

	• Ongoing and future developments	

Term Work
Term work shall comprise of 1. Tutorials 2. MCQ examination

Text Books
1. Daniel Krischen and Goran Strbac, "Fundamental of Power System Economics", John Wiley and Sons Ltd ,2004. 2. Sally Hunt, "Making Competition Work in Electricity", John Wiley and Sons, Inc.,2002
Reference Books
1. Steven Stoft , "Power System Economics: Designing Markets for Electricity" , Wiley-IEEE Press, 2002.

Course Code	Course Name
PE-BTE713	**Power Quality and FACTS**

Course pre-requisites	Power Electronics, Power system

Course Objectives

The objectives of this course are:

1. Understand the characteristics of ac transmission and the effect of shunt and series reactive compensation.
2. Understand the working principles of FACTS devices and their operating characteristics.
3. Understand the basic concepts of power quality.
4. Understand the working principles of devices to improve power quality.

Course Outcomes

Upon successful completion of the course, students should be able to:

1. Assess the various power quality issues and its reasons.
2. Analyze the control techniques for VSI for improvement of power system performance.
3. Analyze and compare the thyristor based and VSI based FACT controllers.
4. Appreciate the HVDC as alternative technology for power transmission.

Course Content

Module No.	*Details*	*Hrs.*
1.	**Power Quality Problems in Distribution Systems:** Power Quality problems in distribution systems: Transient and Steady state variations in voltage and frequency. Unbalance, Sags, Swells, Interruptions, Wave-form Distortions: harmonics, noise, notching, dc- offsets, fluctuations. Flicker and its measurement. Tolerance of Equipment: CBEMA curve.	**04**
2.	**Introduction:** Brief discussion on Transmission line theory, use of voltage source inverters (VSI) for reactive power support, mid-point series and shunt compensation, Discussion on voltage profile at the point of common coupling (PCC), need for load compensation. Load balancing using passive elements, Limitations of load balancing using passive elements	**04**
3.	Use of VSI as a Var generator, Indirect current controlled Synchronous link converter Var Compensator (SLCVC), STATCOM, Various PWM techniques, Harmonic elimination and space vector PWM techniques, , theory and implementation issues, Expression for active and reactive powers in terms of d-q components. Transformation	**06**
4	**Thyristor-based Flexible AC Transmission Controllers**: (FACTS) Description and Characteristics of Thyristor-based FACTS devices: Static VAR Compensators (SVC), Thyristor controlled reactor (TCR), Thyristor switched capacitor (TSC), Fixed capacitor-thyristor controlled reactor (FC-TCR), Thyristor Controlled Series Capacitor (TCSC), Thyristor Controlled Braking Resistor and Single Pole Single Throw (SPST) Switch. Configurations/Modes of Operation, Harmonics and control of SVC and TCSC.	**08**
5	**Voltage Source Converter based (FACTS) Controllers:** Voltage Source Converters (VSC): Six Pulse VSC, Multi-pulse and Multi-level Converters, STATCOM: Principle of Operation, Reactive Power Control: Type I and Type II controllers, Static Synchronous Series Compensator (SSSC). GTO Controlled Series Compensator. Phase Angle regulator.	**10**

	Unified Power Flow Controller (UPFC): Principle of Operation and Control. Working principle of Interphase Power Flow Controller.	
6	**HVDC**: Introduction, various possible HVDC configurations. Components of HVDC systems – converter, transformer, smoothing reactor, harmonic filter, Reactive power support. HVDC Operation of 6-pulse controlled converter in rectifier and inverting mode. Effect of source inductance, equivalent circuit Operation of 12-pulse converter.	**06**
7.	**Control of HVDC system**: Rectifier and inverter characteristics, mode stabilization, current control, voltage dependent current order limit, combined rectifier- inverter characteristics, wave blocking and by-passing, limitation of HVDC system using line commutated converters, modern HVDC systems HVDC light.	**04**

Term Work

Term work shall comprise of

1. Tutorials
2. MCQ examination

Text Books

1. J. Arrillaga, M. R. Watson, S. Chan, Power System Quality Assessment, John Wiley and Sons.
2. Narain G. Hingorani, Laszlo Gyugyi, Understanding FACTS: Concepts and technology of flexible AC transmission systems, IEEE Press
3. K. R. Padiyaar , HVDC Power transmission and system

Reference Books

1. M. H. J. Bollen, Understanding Power Quality Problems, Voltage Sag and Interruptions, New York IEEE press, 2000 Series on Power Engineering.
2. R. C. Dugan, Mark F. McGranghan, Surya Santoso, H. Wayne Beaty, Electrical Power System Quality, McGraw Hill Publication:
3. EnriquesAcha, Manuel Madrigal, Power System Harmonics – Computer Modeling and Analysis, John Wiley and Sons Ltd.
4. Ewald F. Fuchs, Mohammad A. S. Masoum, Power Quality in Power Systems and Electrical Machines.
5. G. J. Heydt, Electric Power Quality, Stars in Circule publications.
6. IEEE Std. 519-1992, IEEE recommended practices and requirements for harmonics control in electrical power system

Course Code	Course Name
PE-BTE714	**Advanced Techniques in Power System Protection**
Course pre-requisites	Power system, Switchgear and Protection

Course Objectives

The objectives of this course are

1. Understand the art and science of numerical relay technology.
2. Demonstrate the hardware description of relaying system.

Course Outcomes

Upon successful completion of the course, students will be able to

1. Analyze & review the operating principles and characteristics of advanced protection relays including Numerical relay.
2. Design protection schemes for transmission lines, transformers, and synchronous generators, using advanced relaying techniques.
3. Evaluate adaptive and wide-area protection schemes for modern power systems, including the use of synchro-phasors and PMUs.
4. Appreciate new trends in relay technologies

Course Content

Module No.	*Details*	*Hrs.*
1	**Review of Relaying Practices:** Evolution of digital relays from electromechanical relays, Review of protection philosophies for transmission lines, generators and transformers. Modeling of Current and voltage transformers	5
2	**Mathematical background to protection algorithms:** Finite difference Techniques, Interpolation formulae: Forward, backward and central difference interpolation, Numerical differentiation, Curve fitting and smoothing, Least squares method, Fourier series and Fourier transform	8
3	**Numerical Relay :** architecture, sampling theorem, anti-aliasing filter, Fourier Algorithm, Full cycle window algorithm for phasor estimation	5
4	**Transmission Line Protection:** Distance relay scheme for three phase line, Different relay algorithms for distance protection, Out of step blocking and tripping schemes.	8
5	**Digital differential Protection**: protection of generator, transformer, bus bar protection, Travelling wave based protection schemes.	8
6	**Adaptive Relaying:** Need for adaptive relaying, Adaptive relaying for transmission lines, transformer, Auto-reclosing.	4
7	**Wide Area Measurement Applications:** WAMS architecture, WAMS based out of step relaying, supervision of back up zones, Intelligent load shedding, and Intelligent islanding.	4

Term Work

Term work shall comprise of

1. Tutorials
2. MCQ examination

Text Books
1. A.G. Phadke and J. S. Thorp, “Computer Relaying for Power Systems”, Wiley/Research studies Press, 2009 **2.** A.T. Johns and S. K. Salman, “Digital Protection of Power Systems”, IEEE Press,1999
Reference Books
1. Gerhard Ziegler, “Numerical Distance Protection”, Siemens Publicis Corporate Publishing, 2006 **2.** S.R. Bhide “Digital Power System Protection” PHI

Course Code	Course Name
PE-BTE715	**Non-linear Control System**

Course pre-requisites	Control System

Course Objectives

The objectives of this course are

1. To introduce the nature of nonlinearities found in systems and control
2. To learn standard methods of analysis and design in nonlinear system

Course Outcomes

Upon successful completion of the course, students should be able to

1. Analyze the behavior of nonlinear control systems and identify common physical nonlinearities.
2. Apply phase plane analysis to study the dynamics of linear and nonlinear systems.
3. Use Lyapunov's direct method to assess system stability and perform control design.
4. Apply describing function technique to evaluate the stability of nonlinear systems.
5. Design control strategies for nonlinear systems using feedback linearization and Lyapunov-based approaches.

Course Content

Module No.	*Details*	*Hrs.*
1	**Non-linear systems:** Introduction, behavior of non-linear system, common physical non linearity- saturation, friction, backlash, dead zone, relay, multi variable non- linearity.	04
2	**Phase Plane Analysis:** Concept of phase plane, constructing phase portrait, Phase plane analysis of linear systems, Phase plane analysis of nonlinear systems, Existence of limit cycles.	07
3	**Fundamentals of Lyapunov theory:** equilibrium points, concept of stability, linearization of nonlinear systems, Local stability, Lyapunov Equation, Lyapunov's direct method, Stability and instability theorems.	08
4	System analysis based on Lyapunov's direct method and Control Design based on Lyapunov's direct method.	06
5	**Describing Functions:** Stability analysis and limit cycles, Linear compensation methods, General describing functions of common nonlinearities, Relative stability.	05
6	**Feedback linearization:** feedback linearization and canonical form, Input-state linearization, Input- output linearization.	05
7	**Control design for nonlinear system:** Control design using linearized model, Lyapunov method of control design, control design using feedback linearization and back stepping.	07

Term Work

Term work shall comprise of

1. Tutorials
2. MCQ examination

Text Books

1. Slotine, J. E. & Weiping Li, Applied Nonlinear Control, Prentice-Hall, [1991]
2. Khalil, Hasan K., Nonlinear Systems, Macmillan Publishing, [1992]

Reference Books

1. Chi-Tsong Chen, "Linear Systems Theory and Design", Oxford University Press New York, 1999.
2. T. Kailath, "Linear Systems", Prentice-Hall, New Jersey, 1980, Science and Business Media 2008.
3. Gilbert Strang, " Linear Algebra and its Application", Fourth Edition CENGAGE Learning
4. Ogata, K., Modern Control Engineering, Prentice-Hall, [2002]

5. Gopal, M., Modern Control System Theory, John Wiley Eastern Ltd. New Delhi, [1984]
6. Friedland, B., Control System Design, McGraw-Hill, [1986]
7. Ogata, K., State Space Analysis of Control Systems, Prentice-Hall, [1967]
8. Kuo, B. C., Automatic Control Systems, Prentice-Hall, [1987]

Course Code	Course Name
PE-BTE721	**Energy storage and Vehicle Management System**

Course pre-requisites	Basics of Batteries, Basic Sensors

Course Objectives
1. To get conversant with the energy sources used in EVs and their state of the art. 2. To understand the various battery charging and management systems
Course Outcomes
Upon successful completion of this course, the learner will be able to: 1. Evaluate the battery specifications using various design considerations for EVs 2. Estimate heat generation and suggest thermal management systems. 3. Integrate different subsystems for electrical vehicles and their management. 4. Illustrate the importance of actuators in modern automotive system.

Course Content

Module No.	***Details***	***Hrs.***
1	**Energy Sources for EV:** Overview of energy sources for electric vehicle: Batteries, Fuel Cell, Ultra-capacitor and flywheel energy storage; Hybridization of energy sources for electric and hybrid vehicles; Comparison of sources. Batteries: Lead-acid battery, Nickel-based batteries, Sodium based batteries, lithium batteries, Metal/air batteries	**08**
2	Battery parameters, Battery pack formation and testing, SoC & SoH, Estimation of SoC. Battery cell balancing, Battery management System (BMS), Thermal and safety considerations in battery pack design. Battery cell packaging, Design of battery pack and safety considerations, High voltage cabling and cut-outs, Battery pack installation. Use of Battery-UC Hybrid source, Fuel Cell (FC): FC management and Hydrogen storage in EV. Voltage and AHr/ kWhr ratings of ES for EV applications: Major design considerations	**06**
3	**Thermal Management System:** Heat Calculation in various subsystems; HVAC system: HVAC compressor drive; Liquid cooling system for Battery, Electric drive and on board charger. Design considerations for thermal management system	**06**
4	**System Integration and Implementation:** Vehicular Power Control Strategy and Energy Management: A Generic Framework, Definition, and Needs, Methodologies for Optimization, Cost Function Optimization, Benefits of Energy Management.	**06**
5	Braking Systems: Energy Consumption in Braking, Braking Power and Energy on Front and Rear Wheels, Brake System of EVs and HEVs, Series Brake-Optimal Feel, Series Brake-Optimal Energy Recovery; Parallel Brake; Antilock Brake System (ABS); Fundamentals of Regenerative Braking.	**06**

	Steering System: In-car system networking, Steering ratio characteristic, Steering Stabilization, Over-steer, understeer, Electric-Power-Assisted Steering (EPAS); Autonomous vehicles, Principle of object detection.	
6	**Automotive sensors / actuators and networking:** Radar Sensor Detectors for Vehicle Safety Systems; Airborne Ultrasonic Imaging: SONAR Based Image Generation for Autonomous Vehicles, Motor angle sensor, Steering angle sensor, acceleration pedal sensor and break pedal sensor, Tyre Pressure Monitoring Systems (TPMS); In Vehicle communication system: CAN, LIN, Ethernet, Flexray	**06**
7	Recent trends in energy storage in Electric Vehicles. Energy storage alternatives for EVs.	**04**

Text/Reference Books:-

1. Electric Powertrain Energy Systems, Power Electronics and Drives for Hybrid, Electric and Fuel Cell Vehicles by John G. Hayes and G. Abas Goodarzi, Wiley, 2018.

2. Handbook of Automotive Power Electronics and Motor Drive Edited by Ali Emadi, CRC Press, 2005

3. Encyclopaedia of Automotive Engineering edited by David Crolla *et al.*, Wiley, 2014

4. Electric and Hybrid Vehicles Technologies, Modeling and Control: A Mechatronic Approach by Amir Khajepour, Saber Fallah and Avesta Goodarzi, Wiley, 2014.

5. Hybrid Electric Vehicles Principles and Applications with Practical Perspectives, Second Edition Chris Mi and M. Abul Masrur, Wiley 2018.

6. Autonomous Vehicles Intelligent Transport Systems And Smart Technologies edited by Nicu Bizon, Lucian Dascalescu and Naser Mahdavi Tabatabaei, Nova Publishers, 2014

7. Energy Management Strategies for Electric and Plug-in Hybrid Electric Vehicles by Sheldon S. Williamson, Springer, 2013

8. Electric and Hybrid Buses for Urban Transport Energy Efficiency Strategies, by Bogdan Ovidiu Varga, Calin Iclodean and Florin Mariasiu, Springer, 2016.

Course Code	Course Name
PE-BTE722	**Modeling and Analysis of Electrical Machines**

Course pre-requisites	Electrical Machines I and II

Course Objectives

The objectives of this course are

1. To understand the representation electrical machines by the set of mathematical equations.
2. To realize the real behaviour of electrical machines.
3. To study the concepts of space phasors and frame transformation

Course Outcomes

Upon successful completion of the course, students should be able to

1. Implement the mathematical representation of electrical machines.
2. Demonstrate the reference frame theory and its application for representation of induction machine model.
3. Analyse the behaviour of induction machine from its mathematical model

Course Content

Module No.	***Details***	***Hrs.***
1	**Magnetically Coupled Circuits:** Coupled Circuit with and without Leakage Linear Magnetic System, Nonlinear Magnetic System, Computer Simulation of Coupled Circuits with and without leakage	5
2	**Electromechanical Energy Conversion:** Energy Relationship, Energy in Coupling Fields, Graphical Interpretation of Energy Conversion, Electromagnetic and Electrostatic Forces and Torques, Steady State and Dynamic Performance of and Electromechanical System	6
3	Machine Windings and Air Gap EMF, Winding Inductances and Voltage Equations: Synchronous Machine, Induction Machine	5
4	**Reference Frame Theory:** Introduction, Equations of Transformation Change of Variables, Stationary Circuit Variables, Transformed to the Arbitrary Frame, Resistive Elements, Inductive Elements, Capacitive Elements, Commonly used Reference Frame, Transformation between Reference Frames, Transformation of a Balanced Set, Balanced Steady State Phasor Relationships, Balanced Steady State Voltage Equations, Variables Observed from Several Frame of Reference	8
5	**Theory of Symmetrical Induction Machines:** Voltage Equations in Machine Variables, Torque Equations in Machine Variables, Equations of Transformation for Rotor Circuits, Voltage Equations in Arbitrary Reference Frame Variables	5
6	**Symmetrical Induction Machines Steady State and Dynamic Characteristics:** Analysis of Steady State Operation, Free Acceleration Characteristics, Free Acceleration Characteristics Viewed from Various Reference Frames, Dynamic Performance during Sudden Changes in Load Torque, Dynamic Performance during a Three Phase fault at Machine Terminals	8

7	**Introduction to Synchronous Machine Theory:** Voltage Equations in Machine Variables, Torque Equations in Machine Variables, Stator Voltage Equations in Arbitrary Reference Frame Variables, Voltage Equations in Rotor Reference Frame Variables- Parks Equations, Torque Equation in Substitute Variables, Rotor Angle and Angle between Rotors.	5

Term Work
Term work shall comprise of 1. Tutorials based on each module in the syllabus content 2. MCQ examination
Text Books
1. R. Krishnan, "Electric Motor & Drives: Modeling, Analysis and Control", Prentice Hall of India 2015. 2. P. C. Krause, "Analysis of Electrical Machinery and Drive System," Wiley IEEE Press, Third edition, 2013
Reference Books
1. Charles Kingsley, Jr., A.E. Fitzgerald, Stephen D. Umans, "Electric Machinery", Tata McGraw Hill, Seventh edition, 2013. 2. Ned Mohan, "Advanced electrical drives Analysis, Control and Modeling using Simulink", Wiley, 2014.

Course Code	Course Name
PE-BTE723	**High Voltage Engineering**

Course pre-requisites	Electromagnetic fields,

Course Objectives

The objectives of this course are

1. To develop an understanding of the fundamental concepts related to high voltage phenomena and insulating media.
2. To explore methods used for the generation and measurement of high voltages and high currents.
3. To apply high voltage engineering principles to assess system behavior and protection mechanisms.
4. To analyze high voltage testing procedures and safety practices in accordance with engineering standards.

Course Outcomes

Upon successful completion of the course, students should be able to

1. **Explain** the physical principles and processes involved in high voltage engineering applications.
2. **Demonstrate** the ability to utilize appropriate methods and tools for high voltage generation and measurement.
3. **Apply** high voltage engineering concepts to evaluate insulation systems and assess system performance under electrical stress.
4. **Analyze** testing methodologies, standards, and safety procedures related to high voltage equipment and laboratories.

Course Content

Module No.	*Details*	*Hrs.*
1	Breakdown in Gases Ionization processes and de-ionization processes, Types of Discharge, Gases as insulating materials, Breakdown in Uniform gap, non-uniform gaps, Townsend‟s theory, Streamer mechanism, Corona discharge	**08**
2	Breakdown in liquid and solid Insulating materials Breakdown in pure and commercial liquids, Solid dielectrics and composite dielectrics, intrinsic breakdown, electromechanical breakdown and thermal breakdown, Partial discharge, applications of insulating materials.	**07**
3	Generation of High Voltages Generation of high voltages, generation of high D. C. and A.C. voltages, generation of impulse voltages, generation of impulse currents, tripping and control of impulse generators	**07**
4	Measurements of High Voltages and Currents Peak voltage, impulse voltage and high direct current measurement method, cathode ray oscillographs for impulse	**07**

	voltage and current measurement, measurement of dielectric constant and loss factor, partial discharge measurements.	
5	Lightning and Switching Over-voltages Charge formation in clouds, Stepped leader, Dart leader, Lightning Surges. Switching over voltages, Protection against over-voltages, Surge diverters, Surge modifiers.	**07**
6	High Voltage Testing of Electrical Apparatus and High Voltage Laboratories Various standards for HV Testing of electrical apparatus, IS, IEC standards, Testing of insulators and bushings, testing of isolators and circuit breakers, testing of cables, power transformers and some high voltage equipment, High voltage laboratory layout, indoor and outdoor laboratories, testing facility requirements, safety precautions in H. V. Labs.	**06**
Term Work		
Term work shall comprise of 1. . Tutorials 2. MCQ examination		

Text Books
1. M. S. Naidu and V. Kamaraju, "High Voltage Engineering", McGraw Hill Education, 2013. 2. C. L. Wadhwa, "High Voltage Engineering", New Age International Publishers, 2007.
Reference Books
1. D. V. Razevig (Translated by Dr. M. P. Chourasia), "High Voltage Engineering Fundamentals", Khanna Publishers, 1993. 2. E. Kuffel, W. S. Zaengl and J. Kuffel, "High Voltage Engineering Fundamentals", Newnes Publication, 2000. 3. R. Arora and W. Mosch "High Voltage and Electrical Insulation Engineering", John Wiley & Sons, 2011. 4. Various IS standards for HV Laboratory Techniques and Testing

Course Code	Course Name
PE-BTE724	**Embedded System**
Course pre-requisites	Microprocessor and Microcontroller

Course Objectives

The objectives of this course are

1. Introduction to embedded system design.
2. Study of ARM processor.
3. Study of ARM programming and hardware interfacing.
4. Understand the design aspects and architectural considerations.

Course Outcomes

Upon successful completion of the course, students should be able to

1. Explain the architecture, design methodology, and operational principles of embedded systems.
2. Explain the ARM architecture including instruction set, programming model and interfacing with external peripheral.
3. Analyze the design consideration and architectural aspects of embedded systems applications.

Course Content

Module No.	***Details***	***Hrs.***
1	**Introduction to Embedded System:** Embedded system overview, An Introduction to Embedded System Architecture, Embedded System Model, Design challenge, Processor Technology, IC Technology.	06
2	**Embedded system Design and development process:** System Design and Development, Life Cycle Models, The Design Process, formulating the requirement specifications, functional design, and architectural design.	06
3	**Introduction to ARM Architecture:** Types of computer Architectures, ISA's and ARM History. Embedded System Software and Hardware, Endianness. Processor core VS CPU core, Operational Modes. Instruction Format, ARM 3 stage Pipeline.	06
4	**ARM Programmer's Model:** ARM Instruction Set, Load Store Instruction, Software Interrupt Instructions, Branch Instructions, Data Processing Instructions, Coprocessor Instruction, Program Status Register Instructions, Loading Constants, Conditional Execution, Addressing Modes, Thumb Instruction Set, Data Processing Instruction, Single Register Load-Store Instruction, Multiple Register Load-Store Instruction, and Stack Instructions.	08
5	**Hardware Interfacing**: GPIO (General Purpose I/O) Programming and Interfacing, Seven- segment LED interfacing, Interfacing to an LCD, keyboard interfacing, UART serial port interfacing, Timer programming, Interrupt and exception programming ADC, DAC and	06

	Sensor interfacing, SPI Protocol and devices.	
6	**Testing, Simulation, and Debugging Techniques and Tools:** Integration and Testing of Embedded Hardware, Testing Methods, Debugging techniques, Laboratory Tools and Target Hardware Debugging.	06
7	**Applications of Embedded Systems:** - Automobiles and in telecommunications - Smart Cards, Missiles and Satellites - Computer Peripherals & Computer Networking - Consumer Electronics	04

For Self-study: Case Study of one application in Industrial automation, Medical, Robotics and Access Control System.

Text Books:

1. Frank Vahid and Tony Givargis , Embedded System Design: A Unified Hardware/Software Approach, Wiley India Wiley; Student edition, 2006.
2. Andrew N. Sloss, Dominic Symes, Chris Wright, ARM System Developer's Guide – Design and optimizing System Software, Morgan Kaufman (Elsevier) Publisher, 2014.
3. Raj kamal, Embedded Systems- Architecture, Programming and Design, McGraw Hill Education; Third edition, 2017.

Reference Books:

1. Jonathan W. Valvano ,Thomson, Embedded Microcomputer Systems, Thomson/Brooks/Cole, 2000.
2. David E. Simon, An Embedded Software Primer, Addison Wesley, 1999.
3. Dr. K.V.K.Prasad, Dreamtech Press, Embedded real time system, Dreamtech Press; New edition, 2003.
4. Shibu K V, Introduction to Embedded Systems, McGraw Hill Education India Private Limited; Second edition, 2017.

E resources (if any):

https://nptel.ac.in/courses/108102045

Course Code	Course Name
OE-BTE701	**Image Processing**
Course pre-requisites	Signals and Systems

Course Objectives

1. To learn the fundamental concepts of Digital Image Processing
2. To learn low, Medium, High level image processing

Course Outcomes

Students will be able to

1. Explain formation of digital image, its modeling and the types.
2. Apply spatial domain image processing algorithms for image enhancement, image segmentation, binary image processing, image compression
3. Apply frequency domain image processing algorithms for image enhancement, image segmentation.

Course Content

Module No.	***Details***	***Hrs.***
1	**Introduction:** Background, Digital Image Representation, Fundamental Steps in Image Processing, Elements of a Digital Image Processing System	04
2	**Digital Image Fundamentals:** Elements of Visual Perception, A Simple Image Model, Sampling and Quantization, Some Basic Relationships between Pixels, Imagining Geometry. Image File Formats: BMP, TIFF and JPEG. Color Models (RGB, HSI, YUV)	06
3	**Image Enhancement:** Spatial Domain Methods, Frequency Domain Methods, Some Simple Intensity Transformations, Histogram Processing, Image Subtraction, Image Averaging, Background Smoothing Filters, Sharpening Filters, Low pass Filtering, High pass Filtering, Generation of Spatial Masks from Frequency Domain Specifications. Homomorphic Filtering	08
4	**Image Segmentation and Representation:** (i) Detection of Discontinuities, Edge Linking using Hough Transform, Thresholding, Region based Segmentation, Split and Merge Technique, **(ii)** Image Representation and Description, Chain Code, Polygonal, Representation, Shape Number, Moments	06
5	**Image Transform:** (i) Introduction to the Fourier Transform, The Discrete Fourier Transform, Some Properties of the Two Dimensional Fourier Transform Fast Fourier Transform(FFT), **(ii)** (ii) Discrete Hadamard Transform(DHT), Fast Hadamard Transform(FHT), Discrete Cosine Transform(DCT), Discrete Wavelet Transform(DWT), **(iii)**	06

6	**Binary Image Processing:** Binary Morphological Operators, Hit-or-Miss Transformation, Boundary Extraction, Region Filling,Thinning and Thickening,	06
7	**Image Compression: Fundamentals –** Coding Redundancy, Inter pixel Redundancy, Psycho visual Redundancy, Fidelity Criteria. Image Compression Models – The Source Encoder and Decoder, Lossless Compression Techniques : Run Length Coding, Arithmetic Coding, Huffman Coding, Differential PCM Lossy Compression Techniques: Improved Gray Scale Quantization, Vector Quantization, JPEG image formation	06

For Self-study: Image restoration, Coding of Image Processing Algorithms.

Text Book:

1. Rafel C. Gonzalez and Richard E. Woods, "Digital Image Processing", 4/e, Pearson Education Asia, 2018

Reference Books

1. S. Jayaraman, E. Esakkirajan and T. Veerkumar, "Digital Image Processing",1/e, Tata McGraw Hill Education Private Ltd, 2009,
2. Anil K. Jain, "Fundamentals and Digital Image Processing", 3/e, Prentice Hall of India Private Ltd

Course Code	Course Name
OE-BTE702	**Artificial Intelligence**
Course pre-requisites	

Course Objectives

The objectives of this course are

1. Introduce to Artificial Intelligence
2. Understand problem solving methods
3. Discuss applications of AI

Course Outcomes

Upon successful completion of the course, students should be able to

1. Explain basic understanding of AI building blocks presented in intelligent agents
2. Choose an appropriate problem solving method and knowledge representation technique, analyze the strength and weaknesses of AI approaches to knowledge – intensive problem solving
3. Design models for reasoning with uncertainty as well as the use of unreliable information

Course Content

Module No.	***Details***	***Hrs.***
1	Introduction to Artificial Intelligence (AI) History of Artificial Intelligence, Intelligent Systems: Categorization of Intelligent System, Components of AI Program, Foundations of AI, Sub- areas of AI, Applications of AI, Current trends in AI	04
2	Intelligent Agents Agents and Environments, The concept of rationality, The nature of environment, The structure of Agents, Types of Agents, Learning Agent	04
3	Problem solving 1 Solving problem by Searching: Problem Solving Agent, Formulating Problems, Example Problems. Uninformed Search Methods: Breadth First Search (BFS), Depth First Search (DFS), Depth Limited Search, Depth First Iterative Deepening(DFID), Informed Search Methods: Greedy best first Search A* Search , Memory bound edheuristic Search.	07
4	Problem solving 2 Local Search Algorithms and Optimization Problems: Hill-climbing search Simulated annealing, Local beam search, Genetic algorithms. Adversarial Search: Games, Optimal strategies, The minimax algorithm, Alpha-Beta Pruning.	07
5	Knowledge based Agents, The Wumpus World,	10

	Forward chaining, backward Chaining, Knowledge Engineering in First-Order Logic, Unification, Resolution, Introduction to logic programming (PROLOG). Uncertain Knowledge and Reasoning: Uncertainty, Representing knowledge in an uncertain domain, The semantics of belief network, Inference in belief network.	
6	Planning and Learning The planning problem, Planning with state space search, Partial order planning, Hierarchical planning, Conditional Planning, Learning: Forms of Learning, Inductive Learning, Learning Decision Tree, Expert System: Introduction, Phases in building Expert Systems, ES Architecture, ES vs Traditional System.	06
7	Applications Natural Language Processing (NLP), Expert Systems.	04

For Self-Study : Propositional logic, First Order Logic: Syntax and Semantic, Inference in FOL

Text Books
1. Stuart J. Russell and Peter Norvig, "Artificial Intelligence A Modern Approach "Fourth Edition" Pearson Education. 2. Saroj Kaushik "Artificial Intelligence" ,Cengage Learning.
Reference Books
1. George F Luger "Artificial Intelligence" Low Price Edition, Sixth edition, Pearson Education. 2. Ivan Bratko "PROLOG Programming for Artificial Intelligence", Fourth Edition, Pearson Education. 3. Elaine Rich and Kevin Knight "Artificial Intelligence" Third Edition, Mc Graw Hill. 4. Davis E.Goldberg, "Genetic Algorithms: Search, Optimization and Machine Learning", Addison Wesley, N.Y., 1989. 5. Hagan, Demuth, Beale, "Neural Network Design" CENGAGE Learning, India Edition

Course Code	Course Name
OE-BTE703	**Medical Electronics**

Course pre-requisites	Electronic circuit, Analog Circuit, Digital Electronics, Communication Engineering

Course Objectives

The objectives of this course are

1. Discuss bioelectric potentials generated in human body
2. Understand the basic principle, working and design of various automated diagnostic equipments.
3. To study various medical instrumentation systems, drug delivery systems and health management systems.

Course Outcomes

Upon successful completion of the course, students should be able to

1. Understand bioelectric potentials generated in human body
2. Use modern methodologies, multi-disciplinary skill set and knowledge while working on real time projects that demand convergence of engineering, science and technology

Course Content

Module No.	*Details*	*Hrs.*
1	**Fundamentals of Medical instrumentation** Generation of Bioelectric Potentials: Basic cell physiology, Physiological systems of body, Sources of biomedical signals. Basic Medical instrumentation system: Performance requirements, intelligent systems	**06**
2	**Biophysical signal capture, processing** Recording electrodes, Electrodes for ECG, EMG, Microelectrodes Physiological Transducers: Classification, Performance characteristics and types of transducers used in medical instrumentation.	**06**
3	**Biomedical Recorders** Electrocardiograph,Vectorcardiograph,Phonocardiograph, Electroencephalograph, Electromayograph	**06**
4	**Monitoring System** Patient monitoring system: Cardiac Monitor, Central Monitors, Measurement of heart rate, temperature, respiratory rate Ambulatory monitoring system: Arrhythmia monitors, ambulatory monitoring instruments Foetal monitoring instrument	**06**
5	**Modern imaging system** Digital radiography, Magnetic Resonance imaging system, Ultasonic Imaging System	**06**
6	**Therapeutic Equipment** Cardiac Pacemakers, Cardiac Defibrillators, Ventilators	**06**
7	**Telemetry, Telemedicine** Single and multi channel telemetry systems, Implantable telemetry system, Essential parametes of telemedicine, telemedicine system, transmission of still and video images, Cyber medicine.	**06**

Text Books
1. Medical Instrumentation, Application and Design by J.G. Webster, TMH.
Reference Books
1. Handbook of Biomedical Engineering by R.S. Khandpur, PHI 2. Encyclopaedia of medical devices and instrumentation - J.G. Webster Vol I, II, III, IV (John Willey)

Engineering Economics

Course Code	Course Name
OE-BTE704	Engineering Economics

Course pre-requisites	Basics of Project Management, statistics and mathematics, general knowledge about working of organizations

Course Objectives

The objectives of this course are

1. Learn the basic concepts of engineering economics.
2. Understand some engineering economics methods for solving problems of present worth, annual cost, rate of return, payback, break even, benefit cost ratio, etc.
3. Learn to evaluate the cost effectiveness of engineering projects on the basis of their economic viability.
4. Understand the concepts of depreciation / appreciation of assets / resources and its impact on their value.

Course Outcomes

Upon successful completion of the course, students should be able to

1. Apply appropriate engineering economics methods for solving problems of present worth, annual cost, rate of return, payback, break even, benefit cost ratio, etc.
2. Evaluate the cost effectiveness of engineering projects on the basis of their economic viability and draw inferences for the investment decisions.
3. Calculate depreciation / appreciation of assets / resources to assess its impact on present or future value.

Course Content

Module No.	*Details*	*Hrs.*
1	**Introduction** • Economics: Flow in an economy, Law of Supply and Demand, • Concept of Engineering Economics: Definition, Scope, Types of Efficiency • Elements of Costs: Marginal Cost, Marginal Revenue, Sunk Cost, Opportunity Cost • Break-Even Analysis, Profit / Volume Ratio **Elementary Economic Analysis** • Basics, Material Selection for a Product, Building Material Selection • Process Planning / Process Modification	03 03
2	**Interest Formulas and Their Applications** • Introduction, Time Value of Money • Interest Formulas: Single Payment Compound Amount, Single-Payment Present Worth Amount, Equal-Payment Series Compound Amount, Equal-Payment Series Sinking Fund, Equal-Payment Series Present Worth Amount, Equal-Payment Series Capital Recovery	03

	Amount, Uniform Gradient Series Annual Equivalent Amount, Effective Interest Rate • Bases for Comparison of Alternatives	
3	**Present Worth Method of Comparison** • Basics, Revenue-dominated Cash Flow Diagram, • Cost-dominated Cash Flow Diagram **Future Worth Method** • Basics, Revenue-dominated Cash Flow Diagram • Cost-dominated Cash Flow Diagram **Annual Equivalent Method** • Basics, Revenue-dominated Cash Flow Diagram • Cost-dominated Cash Flow Diagram • Alternate Approach **Rate of Return Method.** **Advantages and disadvantages of each method.**	06
4	**Replacement and Maintenance Analysis** • Basics, Types of Maintenance, Types of Replacement, • Determination of Economic Life of an Asset • Replacement of Existing Asset with a New Asset: Capital Recovery with Return, Concept of Challenger and Defender • Simple Probabilistic Model for Items Which Fail Completely.	03
5	**Depreciation** • Methods of Depreciation: Straight Line Method of Depreciation, Declining Balance Method of Depreciation, Sum-of-the-Years-Digits Method of Depreciation, Sinking Fund Method of Depreciation, Service Output Method of Depreciation. **Evaluation of Public Alternatives**	03 02
6	**Inventory Control** • Basics, Purchase Model with Instantaneous Replenishment and without Shortages, • Manufacturing Model without Shortages • Purchase Model with Shortages (Instantaneous Supply) • Manufacturing Model with Shortages	04
7	**Make or Buy Decision** • Basics, Criteria for Make or Buy • Approaches for Make or Buy Decision: Simple Cost Analysis, Economic Analysis, Break-even Analysis **Value Engineering** • Basics, Functions, Aim, • When to Apply Value Analysis, Value Analysis vs. Value Engineering • Value Engineering Procedure, Advantages and Application Areas **Mathematical Models for Value Engineering**	02 02 01

Text Books
1. Gerald J. Thuesen, W. J. Fabrycky, "Engineering Economy", 8th Edition, Prentice Hall International Series in Industrial and Systems Engineering. 2. R. Paneerselvam, "Engineering Economics", PHI Learning Pvt. Ltd. New Delhi, 2012. 3. Leland Blank, Anthony Tarquin, "Basics of Engineering Economy, McGraw Hill Higher Education Publications, 2008.
Reference Books
1. Chan S. Park, "Contemporary Engineering Economics", 5th Edition, Pearson Publication. 2. Donald G. Newnan, Jerome P. Lavelle, Ted G. Eschenbach, "Engineering Economic Analysis", 12th Edition, Oxford University Press. 3. DeGarmo, E. Paul, Sallivan and Canada, "Engineering Economy", Collier MacMilan Ltd., USA.

Course Code	Course Name
OE-BTE705	**Internet of Things**
Course pre-requisites	

Course Objectives

The objectives of this course are

1. Students will understand the concepts of Internet of Things and can able to build IoT applications.
2. Explored to the interconnection and integration of the physical world and the cyber space.
3. Students are also able to design & develop IOT Devices.

Course Outcomes

Upon successful completion of the course, students should be able to

1. Explain the concepts of Internet of Things & M2M communication.
2. Classify wireless sensor network and IoT enabling technologies.
3. Analyze various design methodologies for developing IoT applications in different domain.

Course Content

Module No.	***Details***	***Hrs.***
1	**Introduction to IoT:** Concepts, Terminology, components, characteristics, Requirements and Applications of IoT, Physical design of IoT, Logical design of IoT- Functional blocks of IoT, Communication models & APIs.	**06**
2	**IoT & M2M:** Machine to Machine – M2M architecture, applications of M2M, Difference between IoT and M2M, Software Define Network – three layer architecture, key elements of SDN, Network Function Virtualization (NFV).	**06**
3	**Wireless Sensor Networks**: Basics of Wireless sensor networks (WSN), WSN Topologies, WSN Applications, and WSN Node, Architecture components of WSN, Cyber Physical Systems, and Architectural components of CPS.	**06**
4	**IoT Data Sensing and Processing:** Sensors, Sensor Characteristics, Sensing Types, Sensing Consideration, Actuator, Actuator Types, Actuator Characteristics, Data Formats, Processing Topologies, Device Design and Selection Considerations.	**06**
5	**Communication Technologies** – Infrastructure Protocols, Discovery Protocols, Data Protocols, Identification Protocols, Device Management and Semantic Protocols.	**06**
6	**IoT Platform Design Methodology:** Purpose and Requirements specification for IoT platform design, operational view specification, application development.	**06**
7	**Logical Design using Python:** Python Data Types and Data Structures, Control Flow, Functions, Modules, Packages, File Handling, Date/Time Operations, Classes.	**06**

For Self-study: Case Study - Smart Agriculture, Smart Cities, and Smart Environment.

Text Books:

1. Vijay Madisetti, Arshdeep Bahga, "Internet of Things: A Hands-On Approach", Orient Blackswan Private Limited - New Delhi; First edition, 2015.
2. Sudip Mishra, Anandrup Mukharjee, Ajit Roy, "Introduction to IoT" Cambridge University Press; First edition, 2022.

Reference Books:

1. Dieter Uckelmann et.al, "Architecting the Internet of Things", Springer, 2011.
2. Ian R. Sinclair, "Sensors and Transducer", Newnes; 3rd edition, 2000.
3. Charalampos Doukas , "Building Internet of Things with the Arduino", Create space, 2002.

E resources (if any):

https://onlinecourses.nptel.ac.in/noc22_cs96/preview

Project Stage II

Course Code	Course Name
PR-BTE701	**Project Stage II**
Course pre-requisites	All courses till semester VI

Course Objectives

1. Apply multidisciplinary engineering knowledge to identify, analyze, and propose effective solutions for real-world electrical engineering problems.
2. Design and develop electrical systems or prototypes using appropriate tools, technologies, and engineering principles.
3. Demonstrate teamwork, project management, and communication skills through collaborative execution and structured reporting of the project.
4. Understand professional, ethical, and societal responsibilities while considering sustainability and lifelong learning in engineering practices.

Course Outcomes

Upon successful completion of the course, students should be able to

1. Apply basic principles, modern techniques and/or IT tools, experimental/lab data for analysis and solving of the identified problem.
2. Design, simulate, and implement electrical or interdisciplinary systems using modern engineering tools and technologies.
3. Demonstrate effective teamwork, project planning, and technical communication skills through well-documented project reports, presentations, research publications and collaborative work.
4. Exhibit awareness of ethical practices, sustainability, and societal impact in the execution of engineering projects, while engaging in independent learning and continuous improvement.

Value added course

Solar PV Installation

Course Code	Course Name
VE-BTE010	Solar PV Installation
Course pre-requisites	

Course Objectives

1. To impart practical knowledge and hands-on skills related to the installation, testing, and maintenance of solar PV systems.
2. To familiarize participants with real-world tools, site assessment techniques, and safety practices for solar PV installations.

Course Outcomes

Upon successful completion of the course, students should be able to

1. Design, install, and maintain solar PV systems using appropriate tools, components, and standard procedures.
2. Conduct site assessment, perform field measurements, and implement safety compliant installation practices in real-world solar PV projects.

Course Contents

Sr. No.	Details	Hrs
1.	Introduction to Solar Energy & PV Basics	2
2.	Solar PV System Components & Types	3
3.	Tools & Instruments in Solar PV Industry	3
4.	Site Assessment & Survey Techniques	3
5.	Design of a Typical Solar PV System	5
6.	Installation Process of Solar PV Systems	5
7.	Testing, Maintenance & Troubleshooting	4
8.	Safety Practices in Solar PV Installations	3
9.	Site Visit to Ongoing Solar PV Installation Project	4

References:

1. MNRE Installer's Guide: Basic Guidelines for Solar PV System Installation, Ministry of New and Renewable Energy (India)
2. NISE Training Manual: Suryamitra Training Modules, National Institute of Solar Energy (NISE), India
3. Standards (BIS/IEC): IS 16221 (Part 1 & 2), IEC62548, IEC62446-1

Bharatiya Vidya Bhavan's

SARDAR PATEL COLLEGE OF ENGINEERING

(Government Aided Autonomous Institute under Mumbai University) Andheri (W), Mumbai – 400058

COURSE CONTENTS

Sem. VIII

B. Tech. (ELECTRICAL) ENGINEERING

Academic Year: 2025-2026

Note: open courses may be in online mode through online platform such as SWAYAM / NPTEL/ from the list of courses offered by the institute

List of Open Elective (OE-III) courses by the department:

1) OE-BTE801 Computer Network

Computer Network

Course Code	Course Name
OE-BTE801	Computer Network

Course pre-requisites	Communication Engineering

Course Objectives

The objectives of this course are

1. Discuss various types of networks
2. Introduce various layers of computer network protocols

Course Outcomes

Upon successful completion of the course, students should be able to

1. Describe the layered architecture, functions, and protocols of the OSI and TCP/IP models.
2. Analyze network addressing, routing algorithms, and transport layer functionalities.
3. Apply networking principles to demonstrate the operation of application layer protocols.

Course Content

Module No.	*Details*	*Hrs.*
1	OSI reference model and network architecture: Types of communication (simplex, half duplex, full duplex), types of connections, network topology types. Types of networks: peer to peer and client server networks, network hardware- transmission technology-broadcast links and point-to-point links and scale–PAN, LAN, MAN, WAN, Internet. Network software: protocol hierarchies, protocol, peers, interface, network architecture, protocol stack, Connection oriented and connectionless services, service primitives. Reference model: OSI, TCP/IP	**06**
2	Physical layer: Guided Transmission Media, Unguided Transmission Media	**03**
3	Data link layer: Services provided by Data link layer to network layer, Framing Error detection – checksum, parity CRC. Error correction: hamming codes. Flow control- elementary data link protocols, Sliding window protocols HDLC- high level data link control protocol	**07**
4	Medium Access Sub layer: The Channel Allocation Problem, Multiple Access Protocols Multiple access Aloha system, CSMA–CSMA/CD, CSMA/CA Controlled access – reservation system, polling, token passing Channelization–FDMA, TDMA, CDMA. Traditional Ethernet- frame, addressing	**07**
5	Network layer: IPV4 addresses – address space, notations, classful, classless addressing Need for network layer, IPv4 datagram, and fragmentation. Routing table: Static, Dynamic, Routing protocol: Intra domain – Distance vector RIP, link state-	**08**

	OSPF, inter domain – path vector BGP.	
6	Transport layer: Process to process delivery- client server paradigm, multiplexing, demultiplexing, connection less vs connection oriented service. UDP: user datagram, UDP operation: connectionless services, flow and error control, encapsulation and decapsulation, queuing. TCP: TCP services: process to process communication, stream delivery service, sending and receiving buffers, segments, full duplex communication. TCP features: sequence numbers and acknowledgement number, TCP segment, TCP connection, flow control, error control, congestion control.	**08**
7	Application Layer: Remote logging: TELNET, FTP.	**03**

Text Books
1. S. Tanenbaum, "Computer Networks", 4th Edition, Prentice Hall, 2012.
Reference Books
1. B. F. Ferouzan, "Data and Computer Communication", 4 th Edition, Tata McGraw Hill, 2010. 2. William Stallings, "Data and Computer Communication", 10thEdition, 2014